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GATE 2017

Electrical Engineering

(Morning Session : 11-02-2017)

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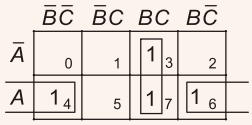
ELECTRICAL ENGINEERING

Q.1 The Boolean expression $AB + A\bar{C} + BC$ simplifies to

(a) $BC + A\bar{C}$ (b) $AB + A\bar{C} + B$

(c) $AB + A\bar{C}$ (d) $AB + BC$

Ans. (a)



$A\bar{C} + BC$

$BC + A\bar{C}$

End of Solution

Q.2 The matrix $A = \begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix}$ has three distinct eigenvalues and one of its eigenvectors is $\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$. Which one of the following can be another eigenvector of A?

(a) $\begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$ (b) $\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$

(c) $\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$ (d) $\begin{bmatrix} 1 \\ -1 \\ 1 \end{bmatrix}$

Ans. (c)

The given matrix is symmetric and all its eigen values are distinct. Hence all its eigen vectors are orthogonal one of the eigen vector is $x_1 = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$.

The corresponding orthogonal vector in the given option is C. i.e. $x_2 = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$

$$x_1^T . x_2 = \begin{bmatrix} 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} = 1 + 0 - 1 = 0$$

End of Solution

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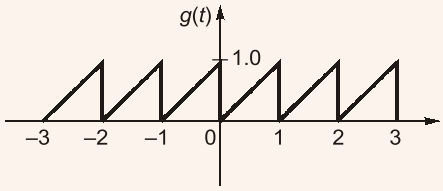
Q.3 Consider $g(t) = \begin{cases} t - \lfloor t \rfloor, & t \geq 0 \\ t - \lceil t \rceil, & \text{otherwise} \end{cases}$, where $t \in R$. Here $\lfloor t \rfloor$ represents the largest integer less than or equal to t and $\lceil t \rceil$ denotes the smallest integer greater than or equal to t. The coefficient of the second harmonic component of the Fourier series representing $g(t)$ is _____ .

Ans. (0.318)

$$g(t) = \begin{cases} t - \lfloor t \rfloor, & t \geq 0 \\ t - \lceil t \rceil, & t < 0 \end{cases}$$

$\lfloor t \rfloor$ is greatest integer less than t.

$\lceil t \rceil$ is smallest integer greater than t.



To calculate Fourier series coefficient we differentiate $g(t)$,

$$g'(t) = \left\{1 + \sum_{k=-\infty}^{\infty} -\delta(t-k)\right\}$$

The Fourier series coefficient of $g'(t)$ will be

$$G'_k = \begin{cases} 1, & k = 0 \\ 0, & k \neq 0 \end{cases} + \{-1 \forall k\}$$

$$G'_k = \begin{cases} 0, & k = 0 \\ -1, & k \neq 0 \end{cases}$$

Thus, $$G_k = \frac{G'k}{j\omega_0 k}$$

and $$G_0 = \frac{1}{1}\int_0^1 g(t)\,dt = \frac{1}{2} \times 1 \times 1 = \frac{1}{2}$$

and $$G_k = -\frac{1}{j\omega_0 k}, \quad k \neq 0$$

$\Rightarrow$ $$G_k = -\frac{1}{j\pi k}, \quad k \neq 0$$

The $$g(t) = \sum_{k=-\infty}^{\infty} G_k e^{j\omega_0 kt}$$

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Since, G_k is imaginary the $g(t)$ will have only sineterms and

$$b_k = \text{coefficient of sineterms}$$

$$= j(G_k - G_{-k}) = j\left(-\frac{1}{j\pi k} - \frac{1}{j\pi k}\right) = \frac{-2}{\pi k}$$

Thus, $$g(t) = 0.5 + \sum_{k=0}^{\infty} b_k \sin\omega_0 kt$$

$$= 0.5 + b_1 \sin\omega_0 t + b_2 \sin 2\omega_0 t + \ldots$$

$\Rightarrow$ 2nd harmonic has coefficient b_2

and $$b_2 = -\frac{2}{\pi k}\bigg|_{k=2} = -\frac{1}{\pi}$$

$\Rightarrow$ $$|b_2| = \frac{1}{3.14} = 0.318$$

End of Solution

Q.4 The slope and level detector circuit in a CRO has a delay of 100 ns. The start-stop sweep generator has a response time of 50 ns. In order to display correctly, a delay line of

(a) 150 ns has to be inserted into the *y*-channel
(b) 150 ns has to be inserted into the *x*-channel
(c) 150 ns has to be inserted into both *x* and *y* channels
(d) 100 ns has to be inserted into both *x* and *y* channels

Ans. (a)

A delay line of 150 ns has to be inserted into the y-channel to get synchronous between sweep signal applied to *x*-plate and test signal applied to *y*-plate.

End of Solution

Q.5 A closed loop system has the characteristic equation given by $s^3+Ks^2+(K+2)s+3 = 0$. For this system to be stable, which one of the following conditions should be satisfied?

(a) $0 < K < 0.5$ (b) $0.5 < K < 1$
(c) $0 < K < 1$ (d) $K > 1$

Ans. (d)

Characteristic equation is,

$s^3 + Ks^2 + (K + 2)s + 3 = 0$

For this system to be stable, using Routh's criterion, we can write,

$$3 < K(K + 2)$$

or $$K^2 + 2K - 3 > 0$$

or $$(K + 3)(K - 1) > 0$$

Here, the valid answer will be out of all the options given.

i.e. $K > 1$.

End of Solution

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Q.6 For the power semiconductor devices IGBT, MOSFET, diode and Thyristor, which one of the following statements is TRUE?

(a) All the four are majority carrier devices.

(b) All the four are minority carrier devices.

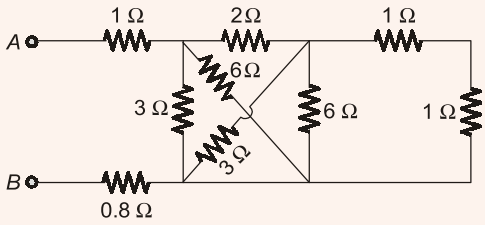
(c) IGBT and MOSFET are majority carrier devices, whereas Diode and Thyristor are minority carrier devices.

(d) MOSFET is majority carrier device, whereas IGBT, Diode, thyristor are minority carrier devices.

Ans. (d)

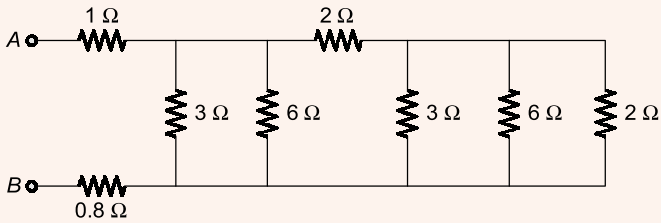
End of Solution

Q.7 The equivalent resistance between the terminals *A* and *B* is _____ Ω.

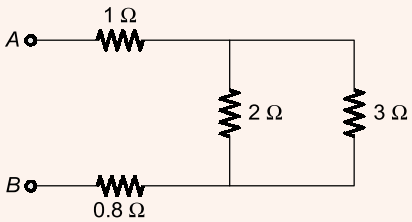


Ans. (3)

Consider the following circuit diagram,



After rearrangement we get,



Now, $R_{AB} = 1 + \frac{6}{5} + 0.8 = 3\ \Omega$

End of Solution

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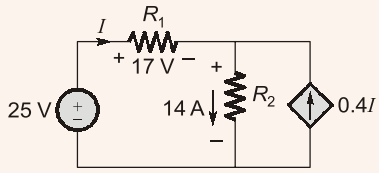
Q.8 The power supplied by the 25 V source in the figure shown below is _____ W.



Ans. (250)

Using KCL at node, we get

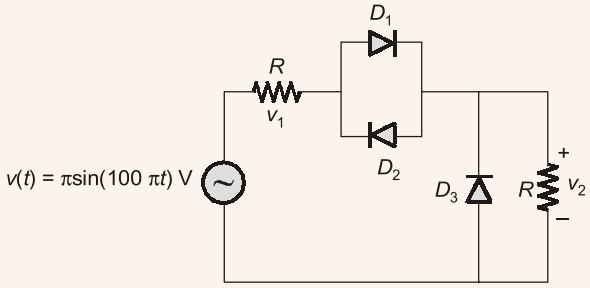
$$I + 0.4I = 14$$

or $$I = 10 \text{ A}$$

Now, power supplied, $P = 25 \times 10 = 250$ W

End of Solution

Q.9 For the circuit shown in the figure below, assume that diodes D_1, D_2 and D_3 are ideal.

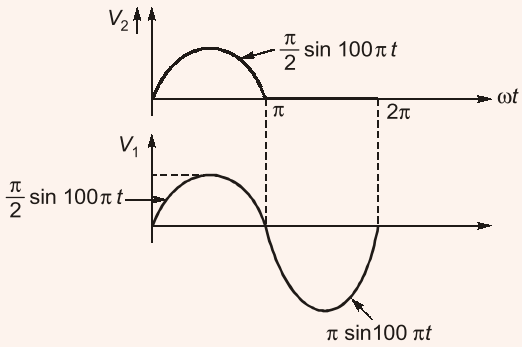


The DC components of voltages v_1 and v_2, respectively are

(a) 0 V and 1 V (b) –0.5 V and 0.5 V

(c) 1 V and 0.5 V (d) 1 V and 1 V

Ans. (b)



$$V_{2\,avg} = \frac{V_m}{\pi} = \frac{\pi/2}{\pi} = \frac{1}{2} = 0.5 \text{ V}$$

$$V_{1\,avg} = \frac{1}{2\pi}\left(\int_0^{\pi}\frac{\pi}{2}.\sin 100\pi t.d(\omega t) + \int_{\pi}^{2\pi}\pi\sin 100\pi t.d(\omega t)\right) = -0.5 \text{ V}$$

End of Solution

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Q.10 A three-phase, 50 Hz, star-connected cylindrical-rotor synchronous machine is running as a motor. The machine is operated from a 6.6 kV grid and draws current at unity power factor (UPF). The synchronous reactance of the motor is 30 Ω per phase. The load angle is 30°. The power delivered to the motor in kW is _____ . (Give the answer up to one decimal place.)

Ans. (726)

$$P = \frac{3.E_{ph}V_{ph}}{X_s}\sin\delta \text{ W}$$

$$\therefore \quad P = \frac{3.\frac{6.6}{\sqrt{3}}\times 1000.\frac{6.6\times 1000}{\sqrt{3}}}{30}\sin(30°)$$

$$\therefore \quad P = 726 \text{ kW}$$

End of Solution

Q.11 The following measurement are obtained on a single phase load: V = 220 V ±1%. I = 5.0 A ± 1% and W = 555 W ± 2%. If the power factor is calculated using these measurements, the worst case error in the calculated power factor in percent is _____. (Give answer up to one decimal place.)

Ans. (4)

$$V = 220 \pm 1\%,$$
$$I = 5 \pm 1\%$$
$$W = 555 \pm 2\%$$
$$W = VI \cdot \cos(\phi)$$

$$\Rightarrow \quad \text{p.f} = \cos(\phi) = \frac{W}{V.I}$$

$$\text{p.f.} = \cos(\phi) = \frac{555 \pm 2\%}{(220 \pm 1\%)(5 \pm 1\%)} = \frac{555}{220\times 5} \pm 4\%$$

$$\text{p.f.} = \cos(\phi) = 0.5 \pm 4\%$$

End of Solution

Q.12 Let $z(t) = x(t) * y(t)$, where "*" denotes convolution. Let c be a positive real-valued constant. Choose the correct expression for $z(ct)$.

(a) $c \cdot x(ct) * y(ct)$ (b) $x(ct) * y(ct)$

(c) $c \cdot x(t) * y(ct)$ (d) $c \cdot x(ct) * y(t)$

Ans. (a)

Time scaling property of convolution.

If, $x(t) * y(t) = z(t)$

then, $x(ct) * y(ct) = \frac{1}{c} z(ct)$

$$\Rightarrow \quad z(ct) = c \cdot x(ct) * y(ct)$$

End of Solution

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Q.13 A 10-bus power system consists of four generator buses indexed at $G1$, $G2$, $G3$, $G4$ and six load buses indexed as $L1$, $L2$, $L3$, $L4$, $L5$, $L6$. The generator-bus $G1$ is considered as slack bus, and the load buses $L3$ and $L4$ are voltage controlled buses. The generator at bus $G2$ cannot supply the required reactive power demand, and hence it is operating at its maximum reactive power limit. The number of non-linear equations required for solving the load flow problem using Newton-Raphson method in polar form is _____.

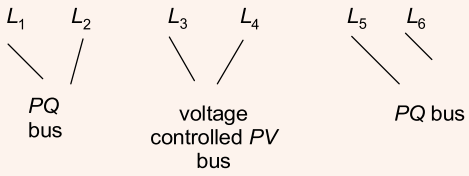
Ans. (14)

Total number of buses ≡ 10

G_1 ≡ slack bus

G_2 ≡ PQ bus (reactive power limit is reached)

G_3, G_4 } PV bus



Minimum number of non linear equations to be solved

= Number of unknown bus voltage variables

= 2 × 10 − 2 − 4 = 14

End of Solution

Q.14 For a complex number z, $\lim\limits_{z\to i}\dfrac{z^2+1}{z^3+2z-i(z^2+2)}$ is

(a) $-2i$ (b) $-i$

(c) i (d) $2i$

Ans. (d)

$$\lim_{Z\to i}\ \frac{z^2+1}{z^3+2z-i(z^2+2)} \qquad \left(\frac{0}{0}\text{ from}\right)$$

$$\lim_{Z\to i}\ \frac{2z}{3z^2+2-i(2z)}$$

$$= \frac{2i}{3i^2+2-i(2i)} = \frac{2i}{-3+2+2} = \frac{2i}{-3+4} = 2i$$

End of Solution

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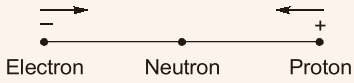
Q.15 Consider an electron, a neutron and a proton initially at rest and placed along a straight line such that the neutron is exactly at the center of the line joining the electron and proton. At $t = 0$, the particles are released but are constrained to move along the same straight line. Which of these will collide first?

(a) the particles will never collide
(b) all will collide together
(c) proton and neutron
(d) electron and neutron

Ans. (d)

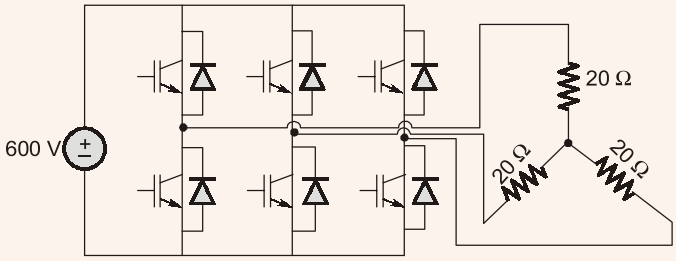
Given that electron, neutron and proton are in a straight line



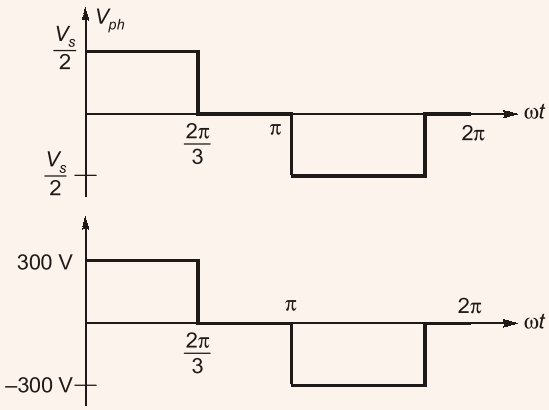
The electron will move towards proton and proton will more towards electron and force will be same $F = \frac{q_1 q_2}{4\pi \epsilon_0 R^2}$. But acceleration of electron will be more than proton as mass of electron < mass of proton. Since neutron are neutral they will not move. Thus electron will hit neutron first.

End of Solution

Q.16 A 3-phase voltage source inverter is supplied from a 600 V DC source as shown in the figure below. For a star connected resistive load of 20 Ω per phase, the load power for 120° device conduction. in kW, is _____ .



Ans. (9)



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$$V_{rms} = \sqrt{\frac{1}{\pi}(300)^2 . \frac{2\pi}{3}} = 300\sqrt{\frac{2}{3}} = 244.94\,V$$

$$3\frac{V^2}{R} = \frac{3\times(244.94)^2}{20} = 9\,kW$$

End of Solution

Q.17 Consider the system with following input-output relation $y[n] = (1 + (-1)^n)\, x[n]$, where $x[n]$ is the input and $y[n]$ is the output. The system is

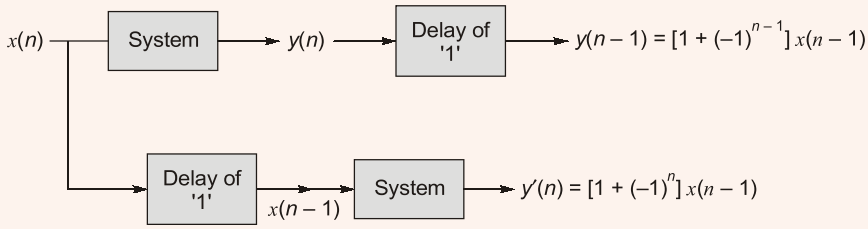
(a) invertible and time invariant
(b) invertible and time varying
(c) non-invertible and time invariant
(d) non-invertible and time varying

Ans. (b)

Given relationship,

$$y(n) = [1 + (-1)^n]\, x(n)$$

Time invariance test:



Since, $y(n-1) \neq y'(n)$

So, the system is time variant.

Invertibility test:

$x(n)$	$y(n)$
$\delta(n)$	$[1+(-1)^n]\,\delta(n) = [1+(-1)^0]\,\delta(n) = 2\delta(n)$
$2\delta(n)$	$[1+(-1)^n]\,2\delta(n) = [1+(-1)^0]\,2\delta(n)$ $= 2\times 2\delta(n) = 4\,\delta(n)$

Thus, we are getting one to one mapping between input and output. So, the system is invertible.

End of Solution

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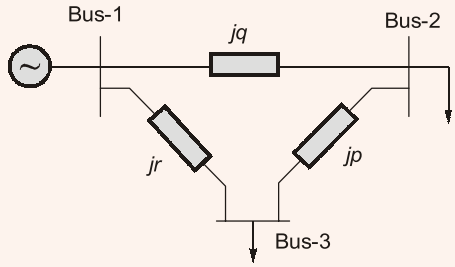
Q.18 A 3-bus power system is shown in the figure below, where the diagonal elements of *Y*-bus matrix are: $Y_{11} = -j12$ pu, $Y_{22} = -j15$ pu and $Y_{33} = -j7$ pu.



The per unit values of the line reactances *p*, *q* and *r* shown in the figure are

(a) $p = -0.2, q = -0.1, r = -0.5$ (b) $p = 0.2, q = 0.1, r = 0.5$

(c) $p = -5, q = -10, r = -2$ (d) $p = 5, q = 10, r = 2$

Ans. **(b)**

Given, $Y_{11} = -j12$ p.u.

$Y_{22} = -j15$ p.u.

$Y_{33} = -j7$ p.u.

We know that,

$$Y_{11} = y_{12} + y_{13} = -j12 \text{ p.u} \quad \ldots(i)$$

$$Y_{22} = y_{12} + y_{23} = -j15 \text{ p.u} \quad \ldots(ii)$$

$$Y_{33} = y_{13} + y_{23} = -j7 \text{ p.u} \quad \ldots(iii)$$

From equation (i) and (ii)

$$y_{13} - y_{23} = j3 \text{ p.u}$$

$$y_{13} + y_{23} = -j7 \text{ p.u.} \quad \ldots(iii)$$

$$y_{13} = -j2 \text{ p.u}$$

$$y_{23} = -j5 \text{ p.u}$$

$$y_{12} = -j10 \text{ p.u}$$

The p.u. values of line reactances p, q and r are

$$jr = \frac{1}{-j2} = j0.5 \text{ p.u.}$$

$$jp = \frac{1}{-j5} = j\,0.2 \text{ p.u.}$$

$$jq = \frac{1}{-j10} = j\,0.1 \text{ p.u.}$$

$\therefore$ p = 0.2, q = 0.1, r = 0.5

End of Solution

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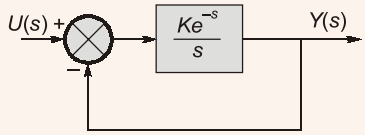
Q.19 Consider the unity feedback control system shown. The value of K that results in a phase margin of the system to be 30° is _____ . (Give the answer up to two decimal places.)



Ans. (1.047)

Forward path transfer function,

$$G(s) = \frac{Ke^{-s}}{s}$$

Given, Phase margin = 30°

or Phase margin = $180° + \phi$

$30° = 180° + \phi$

$\phi = -150°$

$\phi = \angle G(j\omega)_{\omega=\omega_{gc}}$ [where, ω_{gc} is gain crossover frequency]

$\angle G(j\omega) = -90° - 57.3\ \omega°$

At $\omega = \omega_{gc}$ [gain crossover frequency]

$|G(j\omega)| = 1$

or $\frac{K \times 1}{\omega} = 1 \Rightarrow \omega = \omega_{gc} = K$ rad/sec.

$\therefore \angle G(j\omega)_{\omega=\omega_{gc}} = -90° - 57.3\ K$

$-90° - 57.3\ K° = -150°$

$-57.3\ K° = -60°$

$$K = \frac{60}{57.3} = 1.047$$

End of Solution

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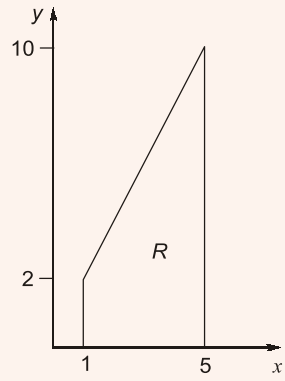
Q.20 Let $I = c\iint_R xy^2 dxdy$, where R is the region shown in the figure and $c = 6 \times 10^{-4}$. The value of I equals _____ . (Give the answer up to two decimal places.)



Ans. (0.99968)

$$I = C\int\int xy^2 dx\, dy$$

$$= C\int_{x=1}^{5}\int_{y=0}^{2x} xy^2 dy\, dx$$

$$= C\int_{1}^{5} x.\left(\frac{y^3}{3}\right)\Big|_0^{2x} dx$$

$$= C\int_{1}^{5} x.\frac{8x^3}{3} dx = C\int_{1}^{5} 8\frac{x^4}{3} dx$$

$$= C.\frac{8}{3}\left(\frac{x^5}{5}\right)\Big|_1^5$$

$$= \frac{8C}{3}\left(5^4 - \frac{1}{5}\right)$$

$$= \frac{8C}{3}(625 - 0.2)$$

$$= \frac{8}{3}\left(6\times 10^{-4}\right)(625 - 0.2) = 0.99968$$

End of Solution

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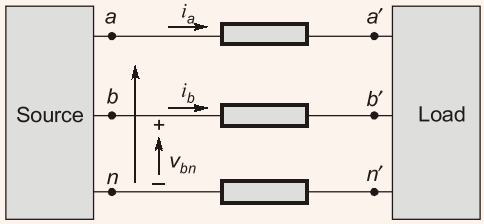
Q.21 A source is supplying a load through a 2-phase, 3-wire transmission system as shown in figure below. The instantaneous voltage and current in phase-*a* are $v_{an} = 220 \sin(100\pi t)$ V and $i_a = 10 \sin(100\pi t)$ A, respectively. Similarly for phase-*b*, the instantaneous voltage and current are $v_{bn} = 220 \cos(100\pi t)$ V and $i_b = 10 \cos(100\pi t)$ A, respectively.



The total instantaneous power flowing from the source to the load is

(a) 2200 W
(b) $2200 \sin^2(100\pi t)$ W
(c) 4400 W
(d) $2200 \sin(100\pi t) \cos(100\pi t)$ W

Ans. (a)

$$V_{an} = 220 \sin(100\pi t)$$
$$i_a = 10 \sin(100\pi t)$$
$$V_{bn} = 220 \cos(100\pi t)$$
$$i_b = 10 \cos(100\pi t)$$
$$p = v_{an}.i_a + v_{bn}.i_b$$
$$\Rightarrow \quad = 2200 \text{ W}$$

End of Solution

Q.22 A 4-pole induction machine is working as an induction generator. The generator supply frequency is 60 Hz. The rotor current frequency is 5 Hz. The mechanical speed of the rotor in RPM is

(a) 1350
(b) 1650
(c) 1950
(d) 2250

Ans. (c)

Induction Generator Mode :

$$N > N_s \quad \text{i.e. } (s \text{ is negative})$$

$\because$ $P = 4$, $f = 60$ Hz, $N_s = 1800$ rpm

Rotor frequency given = 5 Hz $\Rightarrow (s \times f)$

$\because$ $f = 60$ Hz

$$\therefore \quad s = \frac{5}{60} = 0.0833$$

$\because$ It is induction generator slip will be – 0.0833.

$$s = \frac{1800 - N}{1800} = -0.0833$$

$$\therefore \quad N = 1950 \text{ rpm}$$

End of Solution

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Q.23 A solid iron cylinder is placed in a region containing a uniform magnetic field such that the cylinder axis is parallel to the magnetic field direction. The magnetic field lines inside the cylinder will

(a) bend closer to the cylinder axis
(b) bend farther away from the axis
(c) remain uniform as before
(d) cease to exist inside the cylinder

Ans. (a)

Iron being a ferromagnetic material, magnetic lines of force bend closer to cylindrical axis.

End of Solution

Q.24 The transfer function of a system is given by, $\frac{V_0(s)}{V_i(s)} = \frac{1-s}{1+s}$. Let the output of the system be $v_0(t) = V_m \sin(\omega t + \varphi)$ for the input, $v_i(t) = V_m \sin(\omega t)$. Then the minimum and maximum values of φ (in radians) are respectively

(a) $\frac{-\pi}{2}$ and $\frac{\pi}{2}$
(b) $\frac{-\pi}{2}$ and 0
(c) 0 and $\frac{\pi}{2}$
(d) $-\pi$ and 0

Ans. (d)

$$\frac{V_0(s)}{V_i(s)} = \frac{1-s}{1+s} = H(s)$$

For the minimum and maximum values of "ϕ".

$$H(j\omega) = \frac{1-j\omega}{1+j\omega}$$

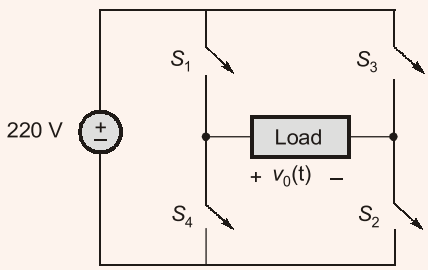
$$\angle H(j\omega) = -2\tan^{-1}\omega$$

At $\omega = 0$; $\angle H(j\omega) = 0°$

At $\omega = \infty$; $\angle H(j\omega) = -\pi$

End of Solution

Q.25 In the converter circuit shown below, the switches are controlled such that the load voltage $v_0(t)$ is a 400 Hz square wave.



The RMS value of the fundamental component of $v_0(t)$ in volts is _____ .

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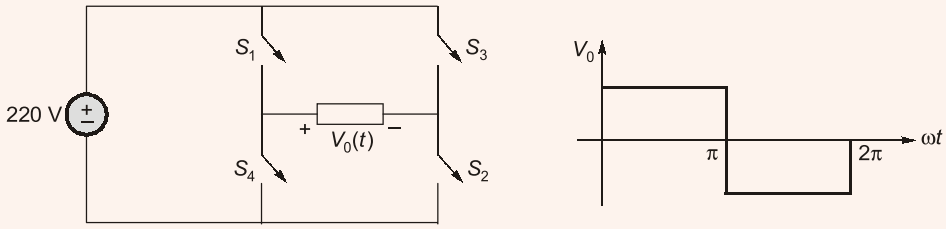
Ans. (198.06)



$$V_{01} = \frac{4V_s}{\sqrt{2}\,\pi} = \frac{4 \times 220}{\sqrt{2}\,\pi} = 198.06 \text{ V}$$

End of Solution

Q.26 A 220 V DC series motor runs drawing a current of 30 A from the supply. Armature and field circuit resistance are 0.4 Ω and 0.1 Ω respectively. The load torque varies as the square of the speed. The flux in the motor may be taken as being proportional to the armature current. To reduce the speed of the motor by 50%, the resistance in ohms that should be added in series with the armature is _____ . (Give the answer up to two decimal places.)

Ans. (10.75)

$$T \propto N^2 \quad \phi \propto I_a \quad T \propto I_a^2$$

$$\therefore \quad N^2 \propto I_a^2$$

$$\therefore \quad \frac{N_2}{N_1} = \frac{I_{a2}}{I_{a1}}$$

$$\therefore \quad 0.5 = \frac{I_{a2}}{30}$$

$$\Rightarrow \quad I_{a2} = 15 \text{ A}$$

For series motor, $\quad \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{a1}}{I_{a2}}$

$$\therefore \quad 0.5 = \frac{E_{b2}}{E_{b1}} \times \frac{30}{15}$$

$$\therefore \quad \frac{E_{b2}}{E_{b1}} = 0.25$$

$$E_{b1} = 220 - 30\,(0.4 + 0.1) = 205 \text{ V}$$

$$\therefore \quad E_{b2} = 51.25 \text{ V}$$

$$\therefore \quad E_{b2} = V - I_{a2}(R_a + R_{se} + R_{ext})$$

$$51.25 = 220 - 15(0.4 + 0.1 + R_{ext})$$

$$\therefore \quad R_{ext} = 10.75\ \Omega$$

End of Solution

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Jatin Kumar	Bivek Joishi	Rachit Jain	Adarsh R.S.	Mahipal Singh	Nitish Garg	Shivam D.	Amrit Anand	Avdhesh	Himanshu Tiwari

ME — 9 Selections in Top 10

AIR-1	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
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Gaurav	B Venkatesh	Tanuj K Sharma	Varsha	Ashish Verma	Mufeed Khan	Shyamji D.	Sk Taushifur R.	Arvind Biswal	Gaurav Tyagi

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AIR-1	AIR-2	AIR-3	AIR-4	AIR-5	AIR-6	AIR-7	AIR-8	AIR-9	AIR-10
Naveen B. Sharma	Amit Rawat	Aswathy S.	Thaduri Naveen	Vinit Ranjan	Harshit Jain	Akash Chhikara	Vivek Jain	Jadugurla N.	Prabhakar

39 Selections in Top 10 | **76** Selections in Top 20 | **505** Selections out of total 604 vacancies

CE	Selections in Top 10 **10**	MADE EASY Selections **182** Out of **225** Vacancies	MADE EASY Percentage **81%**
ME	Selections in Top 10 **9**	MADE EASY Selections **159** Out of **179** Vacancies	MADE EASY Percentage **89%**
EE	Selections in Top 10 **10**	MADE EASY Selections **86** Out of **106** Vacancies	MADE EASY Percentage **81%**
E&T	Selections in Top 10 **10**	MADE EASY Selections **78** Out of **94** Vacancies	MADE EASY Percentage **83%**

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Q.27 Only one of the real roots of $f(x) = x^6 - x - 1$ lies in the interval $1 \le x \le 2$ and bisection method is used to find its value. For achieving an accuracy of 0.001, the required minimum number of iterations is _____ . (Give the answer up to two decimal places.)

Ans. (10)

$$f(x) = x^6 - x - 1$$

$$a = 1 \quad b = 2 \quad \in = 0.01 = 10^{-3}$$

The minimum number of iterations by Bisection method is given by

$$\frac{|b-a|}{2^n} < \in$$

$$\frac{2-1}{2^n} < 10^{-3}$$

$$\frac{1}{2^n} < \frac{1}{10^3}$$

$$2^n > 10^3$$

$$2^n > 1000$$

$$\frac{n}{n_2} > In1000$$

$$n > \frac{In1000}{In2}$$

$$n > 9.96$$

$\therefore$ $n = 10$

End of Solution

Q.28 The transfer function of the system $Y(s)/U(s)$ whose state-space equations are given below is:

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 2 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$$

(a) $\dfrac{(s+2)}{(s^2-2s-2)}$ (b) $\dfrac{(s-2)}{(s^2+s-4)}$

(c) $\dfrac{(s-4)}{(s^2+s-4)}$ (d) $\dfrac{(s+4)}{(s^2-s-4)}$

Ans. (d)

Given, $\dot{X} = \begin{bmatrix} 1 & 2 \\ 2 & 0 \end{bmatrix} X + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u$

and $Y = [1 \quad 0]\, X$

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$$\text{Transfer function} = C[sI - A]^{-1} B + D$$

$$[sI - A]^{-1} = \begin{bmatrix} \frac{s}{s^2 - s - 4} & \frac{2}{s^2 - s - 4} \\ \frac{2}{s^2 - s - 4} & \frac{s-1}{s^2 - s - 4} \end{bmatrix}$$

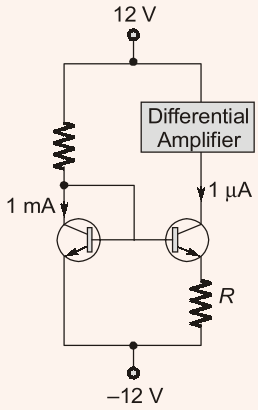
$$(sI - A)^{-1} \cdot B = \begin{bmatrix} \frac{s+4}{s^2 - s - 4} \\ \frac{s-1}{s^2 - s - 4} \end{bmatrix}$$

$$\frac{Y(s)}{U(s)} = C[sI - A]^{-1} \cdot B$$

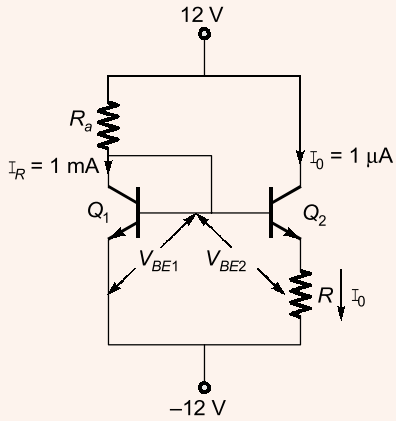
$$= \frac{s+4}{s^2 - s - 4}$$

End of Solution

Q.29 The circuit shown in the figure uses matched transistor with a thermal voltage $V_T = 25$ mV. The base currents of the transistors are negligible. The value of the resistance R in $k\Omega$ that is required to provide 1 μA bias current for the differential amplifier block shown is _____ . (Give the answer up to one decimal place.)



Ans. (172.69)



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$$V_{BE1} = V_{BE2} + I_o R$$
$$I_o R = V_{BE1} - V_{BE2}$$
$$= V_I In\left(\frac{I_R}{I_3}\right) - V_T I_n\left(\frac{I_0}{I_3}\right)$$

Where $I_s \rightarrow$ Reverse saturation current

$$R = \frac{V_T I_n\left(\frac{I_R}{I_0}\right)}{I_0}$$

$$= \frac{0.025 In\left(\frac{1mA}{1\mu A}\right)}{1\mu A} = \frac{0.025 In\left(10^3\right)}{1\mu A} = 172.69\,k\Omega$$

End of Solution

Q.30 Two parallel connected, three-phase, 50 Hz, 11 kV, star-connected synchronous machines A and B, are operating as synchronous condensers. They together supply 50 MVAR to a 11 kV grid. Current supplied by both the machines are equal. Synchronous reactances of machine *A* and machine *B* are 1 Ω and 3 Ω, respectively. Assuming the magnetic circuit to be linear, the ratio of excitation current of machine A to that of machine *B* is _____ . (Give the answer up to two decimal places)

Ans. (0.745)

Synchronous machine *A* : 11 kV, 50 Hz, *Y* connected, X_s = 1 Ω

Synchronous machine *B* : 11 kV, 50 Hz, *Y* connected, X_s = 3 Ω

Given both supplying only reactive power 50 MVAR to 11 kV grid equally

$$\therefore \quad Q_A = \sqrt{3}\, V\, I_A \sin\phi = 25\,MVAR$$

$$Q_B = \sqrt{3}\, V\, I_B \sin\phi = 25\,MVAR$$

$$\therefore \quad I_A = \frac{25\times10^6}{\sqrt{3}\times11\times10^3} = 1312.2\ A$$

$$\therefore \quad I_B = 1312.2\ A$$
$$E_A = V - jI_A X_s$$
$$= \frac{11\times10^3}{\sqrt{3}} - j1312.2\angle90\times1$$
$$E_B = V - jI_B X_s$$
$$= \frac{11\times10^3}{\sqrt{3}} - j1312.2\angle90\times3$$

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Given magnetic circuit to be linear

$\therefore \quad E \propto I_f$

$\therefore \quad \frac{I_{f_A}}{I_{f_B}} = \frac{E_A}{E_B}$

$E_A = 7663.05$ V

$E_B = 10287.45$ V

$\therefore$ Ratio of excitation current of machine A to machine B

$\frac{E_A}{E_B} = 0.745$

End of Solution

Q.31 Consider a causal and stable LTI system with rational transfer function H(z), whose corresponding impulse response begins at $n = 0$. Furthermore, $H(1) = \frac{5}{4}$. The poles of $H(z)$ are $p_k = \frac{1}{\sqrt{2}} \exp\left(j\frac{(2k-1)\pi}{4}\right)$ for $k = 1, 2, 3, 4$. The zeros of $H(z)$ are all at $z = 0$. Let $g[n] = j^n h[n]$. The value of $g[8]$ equals _____ . (Give the answer up to three decimal places.)

Ans. (0.097)

Pole location are given as,

$$z = \frac{1}{\sqrt{2}} e^{j(2K-1)\frac{\pi}{4}}; \qquad K = 1, 2, 3, 4$$

$$z_1 = \frac{1}{\sqrt{2}} e^{j\pi/4} = \frac{1}{2}(1+j)$$

$$z_2 = \frac{1}{\sqrt{2}} e^{j3\pi/4} = \frac{1}{2}[-1+j]$$

$$z_3 = \frac{1}{\sqrt{2}} e^{j5\pi/4} = \frac{1}{2}[-1-j]$$

$$z_4 = \frac{1}{\sqrt{2}} e^{j7\pi/4} = \frac{1}{2}[1-j]$$

Now, $$H(z) = \frac{K \cdot z^4}{(z-z_1)(z-z_2)(z-z_3)(z-z_4)} \qquad ...(1)$$

[As $h(n)$ is causal & it starts from $n = 0$, so numerator will have same order as denominator is having].

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By solving expression (1),

$$H(z) = \frac{KZ^4}{Z^4 + \frac{1}{4}} \qquad \ldots(2)$$

Given that, $H(1) = \frac{5}{4}$

From equation (2), $H(1) = \frac{K}{1+\frac{1}{4}} \Rightarrow \frac{5}{4} = \frac{K}{5/4}$

$$\Rightarrow \quad K = \frac{25}{16}$$

$$H(z) = \frac{\frac{25}{16}z^4}{z^4 + \frac{1}{4}}$$

By using division rule,

$$H(z) = \frac{25}{16}\left[1 - \frac{1}{4}z^{-4} + \frac{1}{16}z^{-8} + \ldots.\right]$$

Thus, $h(8) = \frac{1}{16} \times \frac{25}{16} = 0.097$

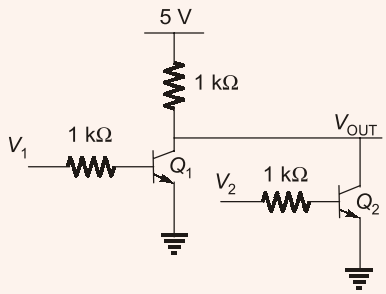
It is given that, $g(n) = j^n h(n)$

$g(8) = j^8 h(8) = h(8)$

$\Rightarrow \quad g(8) = h(8) = 0.097$

End of Solution

Q.32 The logical gate implemented using the circuit shown below where, V_1 and V_2 are inputs (with 0 V as digital 0 and 5 V as digital 1) and V_{OUT} is the output, is



(a) NOT
(b) NOR
(c) NAND
(d) XOR

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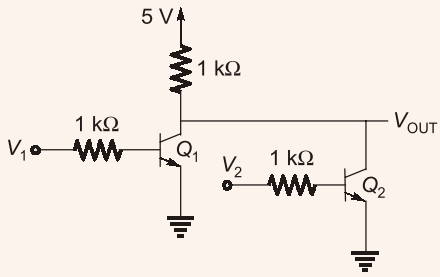
Ans. (b)



When, V_1 = high 5 V Q_1 on V_{out} = 0

V_2 = high 5 V Q_2 on V_{out} = 0

Thus when any V_1 or V_2 is high then

V_{out} = 0

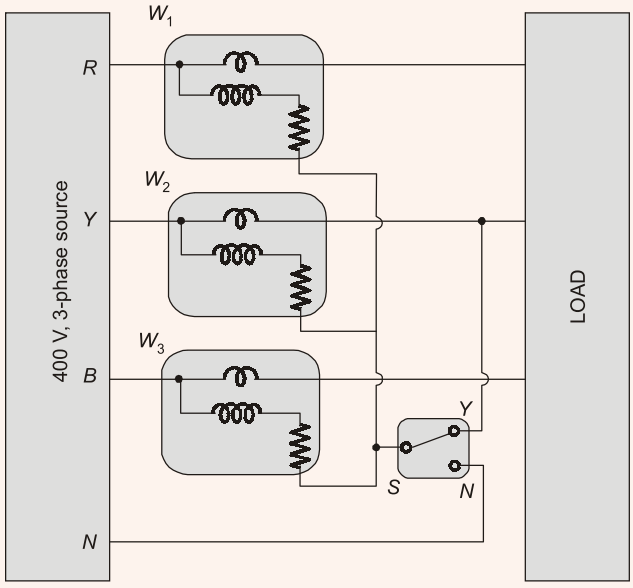
V_1	V_2	V_{out}
0	0	1
0	1	0
1	0	0
1	1	0

$\Rightarrow$

Thus it is a NOR gate.

End of Solution

Q.33 The load shown in the figure is supplied by a 400 V (line-to-line), 3-phase source (RYB sequence). The load is balanced and inductive, drawing 3464 VA. When the switch S is in position N, the three watt-meters W_1, W_2 and W_3 read 577.35 W each. If the switch is moved to position Y, the readings of the wattmeters in watts will be:



(a) W_1 = 1732 and W_2 = W_3 = 0

(b) W_1 = 0, W_2 = 1732 and W_3 = 0

(c) W_1 = 866 and W_2 = 0, W_3 = 866

(d) W_1 = W_2 = 0 and W_3 = 1732

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Ans. (d)

When switch is on Neutral side

$$W = W_1 + W_2 + W_3$$

$$= 577.35 + 577.35 + 577.35 = 1732 \text{ Watts}$$

$$VA \text{ load} = 3464 = 3\ V_{ph} \cdot I_{ph}$$

$$\Rightarrow \quad V_{ph} \cdot I_{ph} = 1154.66$$

$$\text{Each W meter reading} = V_{RN} \cdot I_R \cdot \cos(\angle V_{RN} \text{ \& } I_R)$$

$$577.35 = V_{Ph} \cdot I_{ph} \cdot \cos(\phi)$$

$$\Rightarrow \quad \cos(\phi) = \frac{577.35}{1154.66} = 0.5$$

$$\phi = \cos^{-1}(0.5)$$

$$\Rightarrow \quad \phi = 60^\circ$$

When switch is on Y-phase side

$$W_1 = V_{RY} \cdot I_R \cos(\angle V_{RY} \text{ and } I_R)$$

$$= \sqrt{3} . V_{ph} . I_{ph} . \cos(30^\circ + \phi)$$

$$W_1 = \sqrt{3} \times 1154.66 \times \cos(30^\circ + 60^\circ) = 0 \text{ Watt}$$

$$W_3 = V_{BY} \cdot I_R \cdot \cos(\angle V_{BY} \text{ and } I_B)$$

$$= \sqrt{3} . Y_{ph} . I_{ph} . \cos(30^\circ - \phi)$$

$$W_3 = \sqrt{3} \times 1154.66 \times \cos(30^\circ - 60^\circ) = 1732 \text{ Watts}$$

$$W_1 = 0$$

$$W_2 = 0$$

$$W_3 = 1732 \text{ Watts}$$

End of Solution

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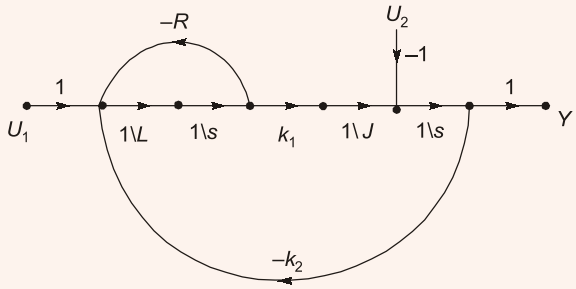
Q.34 In the system whose signal flow graph is shown in figure, $U_1(s)$ and $U_2(s)$ are inputs.

The transfer function $\frac{Y(s)}{U_1(s)}$ is



(a) $\frac{k_1}{JLs^2 + JRs + k_1k_2}$

(b) $\frac{k_1}{JLs^2 - JRs - k_1k_2}$

(c) $\frac{k_1 - U_2(R + sL)}{JLs^2 + (JR - U_2L)s + k_1k_2 - U_2R}$

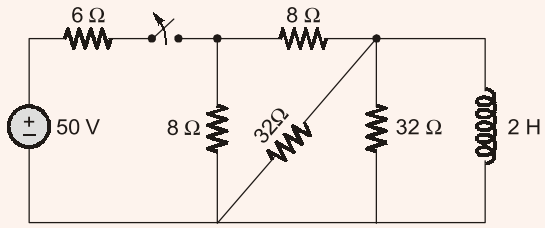
(d) $\frac{k_1 - U_2(sL - R)}{JLs^2 - (JR + U_2L)s - k_1k_2 + U_2R}$

Ans. (a)

Transfer function, $\frac{Y(s)}{U_1(s)} = \frac{\frac{K_1}{LJs^2}[1]}{1 - \left[-\frac{R}{LS} - \frac{K_1K_2}{LJs^2}\right]} = \frac{K_1}{LJs^2 + RJs + K_1K_2}$

End of Solution

Q.35 The switch in the figure below was closed for a long time. It is opened at $t = 0$. The current in the inductor of 2 H for $t \geq 0$, is



(a) $2.5\,e^{-4t}$

(b) $5\,e^{-4t}$

(c) $2.5\,e^{-0.25t}$

(d) $5\,e^{-0.25t}$

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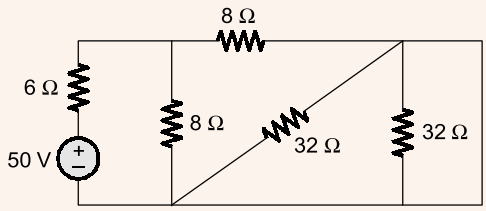
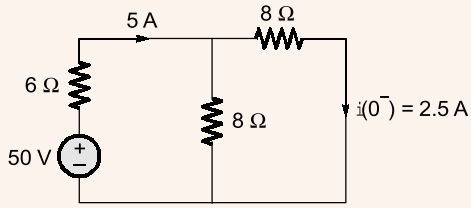
Ans. (a)

From the given circuit, consider the following circuit diagram,



After rearrangement,



for $t \geq 0$;

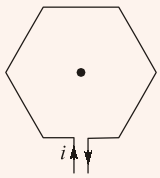
$$I_0 = i(0^-) = 2.5 \text{ A}$$

we can write, $i(t) = I_0 e^{-\frac{Rt}{L}}$

$$i(t) = 2.5\ e^{-4t}\ A$$

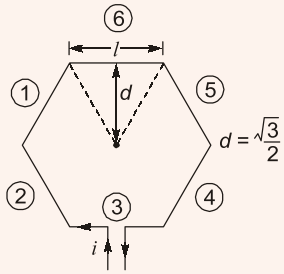
End of Solution

Q.36 The magnitude of magnetic flux density (B) in micro Teslas (μT), at the centre of a loop of wire wound as a regular hexagon of side length 1 m carrying a current (I = 1 A) and placed in vacumm as shown in the figure is _____ . (Give the answer up to two decimal places.)



Ans. (0.69)

i = 1 A



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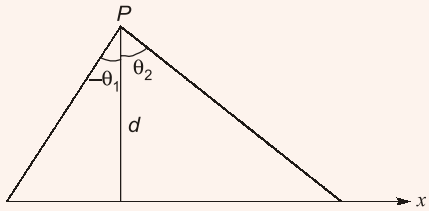
Here B at point P is

$$B = \frac{\mu_0 I}{4\pi d}(\sin\theta_1 + \sin\theta_2)$$



For each segment of hexagon (1, 2, 3, 4, 5, 6)

$$\Rightarrow \quad B = \frac{6\mu_0 I}{4\pi d}(\sin\theta_1 + \sin\theta_2)$$

Here, $d = \frac{\sqrt{3}}{2} l$ (Where l = 1 m)

and $\theta_1 = \theta_2 = 30°$

$$\Rightarrow \quad B = \frac{6 \times \mu_0 I}{\frac{4\pi\sqrt{3}}{2}}(\sin 30° + \sin 30°) = \frac{4\pi \times 10^{-7} \times 6 \times 1}{4\pi \times \frac{\sqrt{3}}{2}}(1)$$

$$= \frac{12}{\sqrt{3}} \times 10^{-7} = \frac{1.20}{\sqrt{3}} \times 10^{-6}\ T$$

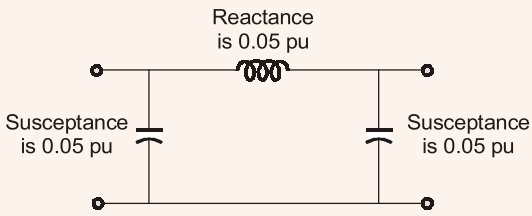
$$B = 0.69\ \mu T$$

End of Solution

Q.37 The bus admittance matrix for a power system network is

$$\begin{bmatrix} -j39.9 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j39.9 \end{bmatrix} \text{p.u.}$$

There is a transmission line, connected between buses 1 and 3, which is represented by the circuit shown in figure.



If this transmission line is removed from service, what is the modified bus admittance matrix?

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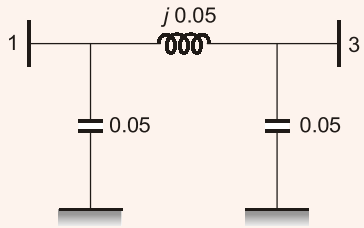
(a) $\begin{bmatrix} -j19.9 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.9 \end{bmatrix}$ p.u. (b) $\begin{bmatrix} -j39.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j39.95 \end{bmatrix}$ p.u.

(c) $\begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix}$ p.u. (d) $\begin{bmatrix} -j19.95 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j19.95 \end{bmatrix}$ p.u.

Ans. (c)

$$Y_{bus} = \begin{bmatrix} -j39.9 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j39.9 \end{bmatrix}$$



Reactance is eliminated in between Bus 1 and 3.

$$y_{11\,(new)} = y_{11(old)} + j\frac{1}{0.05}$$
$$= -j\ 39.9 + j\ 20$$
$$= -j\ 19.99$$

$$y_{33\,(new)} = y_{33(old)} + \frac{j}{0.05}$$
$$= -j39.9 + j20 = -j19.99$$

$$y_{13\,(new)} = y_{13(old)} + \frac{j}{0.05} = j20 - j20 = 0$$

$$y_{31\,(new)} = y_{31(old)} - \frac{j}{0.05}$$
$$= j20 - j20 = 0$$

So, modified admittance matrix.

$$= \begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix} pu$$

End of Solution

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Q.38 A 375 W, 230 V, 50 Hz capacitor start single-phase induction motor has the following constants for the main the auxiliary windings (at starting): $Z_m = (12.50 + j15.75)\ \Omega$ (main winding). $Z_a = (24.50 + j12.75)\ \Omega$ (auxiliary winding). Neglecting the magnetizing branch, the value of the capacitance (in μF) to be added in series with the auxiliary winding to obtain maximum torque at starting is _____ .

Ans. (98.93)

$$Z_a = (24.5 + j12.75)\Omega$$

Let X_c be the reactance of the capacitor connected in the auxiliary winding.

$\therefore$ $Z_a = 24.5 + j12.75 - jX_c$

Let $Z_a = 24.5 - jX_a$

where $X_a = X_c - 12.75$

Given $Z_M = 12.5 + j15.75 = 20.1\angle 51.56°$

$\therefore$ Current in main winding (I_m) lags V by 51.56°

To obtain maximum torque current in both windings has to be in quadrature with each other. (Angle between both currents should be 90°)

$\therefore$ $\phi_a = 90° - 51.56° = 38.44°$

$\therefore$ For auxiliary winding

$$\text{Tan}\phi_a = \frac{X_a}{R}$$

$$\therefore \quad \text{Tan}(38.44) = \frac{X_a}{24.5}$$

$$\therefore \quad X_a = 19.44\ \Omega$$

$$\therefore \quad X_c - 12.75 = 19.44$$

$$\therefore \quad X_c = 32.19\ \Omega$$

$$\text{Capacitive Reactance } X_c = \frac{1}{2\pi fc}$$

$$\therefore \quad C = \frac{1}{2\pi f X_c} = \frac{1}{2 \times 3.14 \times 50 \times 32.19} = 98.93\ \mu\text{F}$$

End of Solution

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Q.39 For a system having transfer function $G(s) = \dfrac{-s+1}{s+1}$, a unit step input is applied at time $t = 0$. The value of the response of the system at $t = 1.5$ sec (rounded off to three decimal places) is _____ .

Ans. (0.554)

$$G(s) = \frac{-s+1}{s+1}$$

System output,

$$Y(s) = G(s)\cdot\frac{1}{s} = \frac{-s+1}{s+1}\cdot\frac{1}{s} = \frac{1}{s} - \frac{2}{s+1}$$

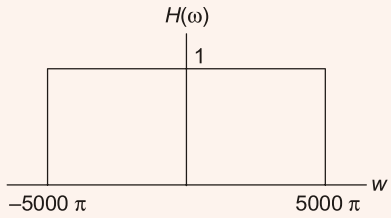
$$y(t) = u(t) - 2e^{-t}\,u(t)$$

$$y(1.5) = 1 - 2e^{-1.5}$$

$$= 1 - 0.446 = 0.554$$

End of Solution

Q.40 Let the signal $x(t) = \sum_{k=-\infty}^{+\infty} (-1)^k \delta\left(t - \dfrac{k}{2000}\right)$ be passed through an LTI system with frequency response $H(\omega)$, as given in the figure below



The Fourier series representation of the output is given as

(a) $4000 + 4000\cos(2000\pi t) + 4000\cos(4000\pi t)$

(b) $2000 + 2000\cos(2000\pi t) + 2000\cos(4000\pi t)$

(c) $4000\cos(2000\pi t)$

(d) $2000\cos(2000\pi t)$

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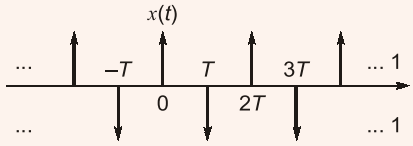
Ans. (c)

$$x(t) = \sum_{K=-\infty}^{\infty} (-1)^K \, \delta\left(t - \frac{K}{2000}\right)$$

$$= \sum_{K=-\infty}^{\infty} (-1)^K \, \delta(t - KT)$$

where, $T = \dfrac{1}{2000}$



Time period: $T_0 = 2T = \dfrac{1}{1000}$

$$\omega_0 = \frac{2\pi}{10} = 2000\pi \text{ rad}$$

Since, $x(t)$ is even-half wave symmetric. So, its expansion will contain only odd harmonics. Therefore, coefficient of 2nd harmonic is

$$a_2 = \frac{2}{T} \int_{-T_0/2}^{T_0/2} x(t) \cos 2\omega_0 t \, dt$$

$$= \frac{4}{T_0} \int_{0}^{T_0/2} \delta(t) \cdot \cos 2\omega_0 t \, dt$$

$$= \frac{4}{T_0} \int_{0}^{T_0/2} \delta(t) \cdot \cos 0 \, dt$$

$$= \frac{4}{T_0} \left[\int_{0}^{T_0/2} \delta(t) \, dt \right] = \frac{4}{T_0} = 4000$$

Now, frequency components available in expansion are

$\omega_0, 3\omega_0, \ldots\ldots$

$2000\pi, 6000\pi, \ldots\ldots$

As, LTI system given in the question will pass upto 5000π rad/sec frequency component of input. So, output will have only one component of frequency 2000π rad/sec.

Thus, $y(t)$ = expansion of output

$= a_2 \cos 2\omega_0 t$

$= 4000 \cos 2000\pi t$

End of Solution

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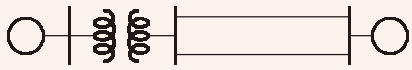
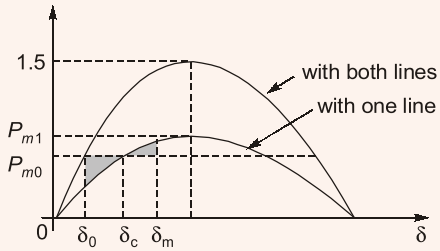
Q.41 The figure shows the single line diagram of a power system with a double circuit transmission line. The expression for electrical power is 1.5 sin δ, where δ is the rotor angle. The system is operating at the stable equilibrium point with mechanical power equal to 1 pu. If one of the transmission line circuits is removed the maximum value of δ, as the rotor swings is 1.221 radian. If the expression for electrical power with one transmission line circuit removed is P_{max} sin δ , the value of P_{max}, in pu is _____ . (Give the answer up to three decimal places.)



Ans. (1.064)



Using equal area criteria:

$$A_1 = A_2$$

$$\int_{\delta_0}^{\delta_c} (P_{mo} - P_{max1}\sin\delta)\,d\delta = \int_{\delta_c}^{\delta_2} (P_{max1}\sin\delta - P_{mo})\,d\delta$$

By solving above integration,

$$P_{max1} = \frac{P_{mo}(\delta_2 - \delta_0)}{\cos\delta_0 - \cos\delta_2}$$

Given data: $P_{m0} = 1$ pu

$P_e = 1.5\sin(\delta_0) = P_{m0} = 1$ pu

$\delta_0 = 41.8° = 0.7295$ rad

$\delta_2 = 1.221$ rad $= 69.95°$

substitute above values in above equation

$$P_{max1} = \frac{1(1.221 - 0.7295)}{\cos 41.8 - \cos 69.95}$$

$$P_{max1} = 1.22$$

End of Solution

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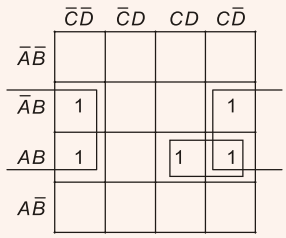
Q.42 The output expression for the Karnaugh map shown below is

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	1	1
10	0	0	0	0

(a) $B\bar{D} + BCD$ (b) $B\bar{D} + AB$

(c) $\bar{B}D + ABC$ (d) $B\bar{D} + ABC$

Ans. (d)



$ABC + B\bar{D}$

End of Solution

Q.43 Let a causal LTI system be characterized by the following differential equation, with initial rest condition

$$\frac{d^2y}{dt^2} + 7\frac{dy}{dt} + 10y(t) = 4x(t) + 5\frac{dx(t)}{dt}$$

Where, $x(t)$ and $y(t)$ are the input and output respectively. The impulse response of the system is ($u(t)$ is the unit step function)

(a) $2e^{-2t}u(t) - 7e^{-5t}u(t)$ (b) $-2e^{-2t}u(t) + 7e^{-5t}u(t)$

(c) $7e^{-2t}u(t) - 2e^{-5t}u(t)$ (d) $-7e^{-2t}u(t) + 2e^{-5t}u(t)$

Ans. (b)

$$\frac{d^2y}{dt^2} + 7\frac{dy}{dt} + 10y = 4x + 5\frac{dx}{dt}$$

$$(s^2 + 7s + 10)\, Y(s) = (4 + 5s)\, X(s)$$

$$\frac{Y(s)}{X(s)} = \frac{5s+4}{s^2+7s+10}$$

Impulse response $= \mathcal{L}^{-1}$ (Transfer function)

$$= \mathcal{L}^{-1}\frac{5s+4}{(s+2)(s+5)} = \mathcal{L}^{-1}\left[-\frac{2}{s+2} + \frac{7}{s+5}\right]$$

$$= -2e^{-2t}u(t) + 7e^{-5t}u(t)$$

End of Solution

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Q.44 A three-phase, three winding Δ/Δ/*Y* (1.1 kV/6.6 kV/400 V) transformer is energized from AC mains at the 1.1 kV side. It supplies 900 kVA load at 0.8 power factor lag from the 6.6 kV winding and 300 kVA load at 0.6 power factor lag from the 400 V winding. The RMS line current in ampere drawn by the 1.1 kV winding from the mains is _____. (Give the answer up to one decimal place.)

Ans. (560.3)

Load on 6.6 kV winding = 900 kVA @ 0.8 pf lag

$$\therefore \quad I_2 = \frac{900\times10^3}{\sqrt{3}\times6.6\times10^3} \Rightarrow 78.73\angle -36.86^\circ \text{ A}$$

Transformation Ratio $k = \frac{1.1}{6.6} = \frac{1}{6}$

$$\therefore \quad I_2' = \frac{I_2}{k} = 472.4\angle -36.86^\circ A$$

Load on 400 V winding = 300 kVA @ 0.6 pf

$$\therefore \quad I_3 = \frac{300\times10^3}{\sqrt{3}\times400} \Rightarrow 433.025\angle -53.13^\circ \text{ A}$$

$$\text{Transformation ratio} = \frac{1.1\times1000}{\frac{400}{\sqrt{3}}} = 4.76$$

$$I_3' = \frac{I_3}{k} = \frac{433.025}{4.76} = 90.97\angle -53.13^\circ$$

So line value of current $= \sqrt{3}\times90.97\angle -53.13^\circ$

$= 157.56\angle -53.13^\circ$

Current drawn by 1.1 kV winding will be

$$I_1 = I_2' + I_3' = 472.4\angle -36.86 + 157.56\angle -53.13^\circ$$

$= 377.96 - j283.37 + 94.53 - j126.04$

$= 472.49 - j\ 409.41 = 625.19\angle -40.9^\circ$ A

End of Solution

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Q.45 Consider the differential equation $(t^2 - 81)\frac{dy}{dt} + 5t\,y = \sin(t)$ with $y(1) = 2\pi$. There exists a unique solution for this differential equation when t belongs to the interval

(a) $(-2, 2)$ (b) $(-10, 10)$

(c) $(-10, 2)$ (d) $(0, 10)$

Ans. **(a)**

The differential equation

$$(t^2 - 81)\frac{dy}{dt} + 5 + y = \sin t$$

$$\frac{dy}{dt} + \frac{5t}{t^2 - 81}y = \frac{\sin t}{t^2 - 81}$$

$$P = \frac{5t}{t^2 - 81}$$

$$Q = \frac{\sin t}{t^2 - 81}$$

$$I.F = e^{\int P dt} = e^{\int \frac{5t}{t^2-81}\,dt}$$

$$= e^{\frac{5}{2}\int \frac{2t}{t^2-81}\,dt} = e^{\frac{5}{2}\ln(t^2-81)}$$

$$= e^{\ln(t^2-81)^{5/2}} = (t^2 - 81)^{\frac{5}{2}}$$

Solution is

$$y(t^2 - 81)^{\frac{5}{2}} = \int \frac{\sin t}{t^2 - 81} \cdot (t^2 - 81)^{\frac{5}{2}}\,dt$$

$$y = \frac{\int (\sin t)(t^2 - 81)^{3/2}\,dt}{(t^2 - 81)^{5/2}} + \frac{C}{(t^2 - 81)^{5/2}}$$

The solution exists for $t \neq -9$.

$t \neq +9$

Hence option (a) is correct.

Because the remaining option are involving either 9 or (–9).

End of Solution

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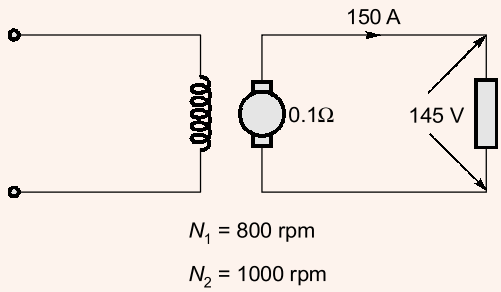
Q.46 A separately excited DC generator supplies 150 A to a 145 V DC grid. The generator is running at 800 RPM. The armature resistance is 0.1 Ω. If the speed of the generator is increased to 1000 RPM, the current in amperes supplied by the generator to the DC grid is _____ . (Give the answer up to one decimal place.)

Ans. (187.5)



Load Resistance $R_L = \dfrac{145}{150} = 0.97\ \Omega$

$$E_{g1} = V + I_a R_a = 145 + 150\ (0.1)$$

$\therefore$ $E_{g1} = 160$ V

$\therefore$ $\dfrac{E_{g2}}{E_{g1}} = \dfrac{N_2}{N_1}$

$\Rightarrow$ $E_{g2} = \dfrac{1000}{800} \times 160 = 200$ V

New load current supplied to grid is

$$I = \frac{E_{g2}}{R_a + R_L} = \frac{200}{0.1 + 0.97} = 187.5 \text{ A}$$

End of Solution

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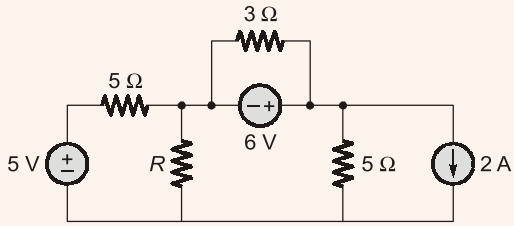
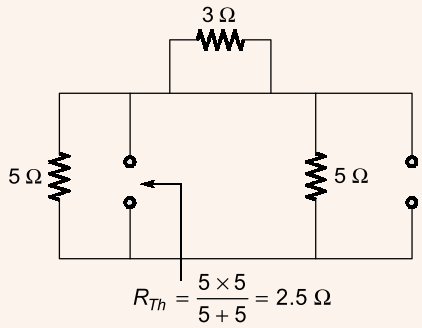
Q.47 In the circuit shown below, the maximum power transferred to the resistor R is _____ W.



Ans. (3.025)

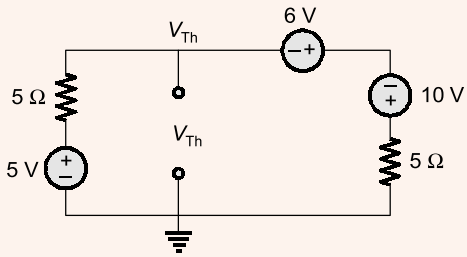
To get R_{th} and V_{th}, consider the following steps.

Case-1: For R_{th}



$$R_{th} = 2.5\ \Omega$$

Case-2: For V_{th}



Applying KCL at node,

$$\frac{V_{th}-5}{5}+\frac{V_{th}+16}{5}=0$$

$$2\ V_{th} = -11$$

$$V_{th} = -5.5\ \text{V}$$

Maximum power transferred,

$$P_{max} = \frac{V_{th}^2}{4R_L} = 3.025\ \text{W}$$

End of Solution

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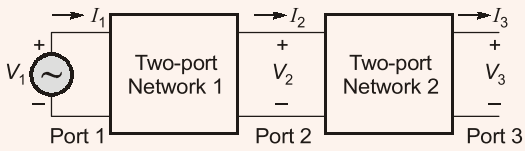
Q.48 Two passive two-port networks are connected in cascade as shown in figure. A voltage source is connected at port 1.



Given,

$$V_1 = A_1V_2 + B_1I_2$$
$$I_1 = C_1V_2 + D_1I_2$$
$$V_2 = A_2V_3 + B_2I_3$$
$$I_2 = C_2V_3 + D_2I_3$$

A_1, B_1, C_1, D_1, A_2, B_2, C_2 and D_2 are the generalized circuit constants. If the Thevenin equivalent circuit at port 3 consists of a voltage source V_T and an impedance Z_T, connected in series, then

(a) $V_T = \dfrac{V_1}{A_1A_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

(b) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2}$

(c) $V_T = \dfrac{V_1}{A_1 + A_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1 + A_2}$

(d) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}, Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

Ans. **(d)**

For two port networks we can write,

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix}\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

or $$A = A_1A_2 + B_1C_2 \quad ...(i)$$

$$B = A_1B_2 + B_1D_2 \quad ...(ii)$$

or $$V_1 = AV_2 - BI_2 \quad ...(iii)$$

To get, $V_T\,(I_2 = 0)$; from equation (iii)

$$V_2 = V_T = \frac{V_1}{A} = \frac{V_1}{A_1A_2 + B_1C_2}$$

To get $Z_T\,(V_1 = 0)$; from equation (iii),

$$V_1 = AV_2 - BI_2$$
$$0 = AV_2 - BI_2$$

$$Z_T = \frac{V_2}{I_2} = \frac{B}{A} = \frac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$$

End of Solution

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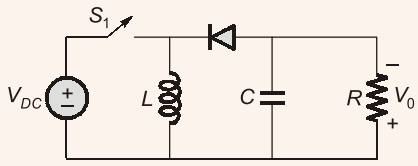
Q.49 The input voltage V_{DC} of the buck-boost converter shown below varies from 32 V to 72 V. Assume that all components are ideal, inductor current is continuous and output voltage is ripple free. The range of duty ratio D of the converter for which the magnitude of the steady-state output voltage remains constant at 48 V is



(a) $\frac{2}{5} \le D \le \frac{3}{5}$

(b) $\frac{2}{3} \le D \le \frac{3}{4}$

(c) $0 \le D \le 1$

(d) $\frac{1}{3} \le D \le \frac{2}{3}$

Ans. (a)

$$V_0 = \frac{\alpha V_s}{1-\alpha}$$

When $V_s = 32$ V and $V_0 = 48$ V

$$\alpha = \frac{3}{5}$$

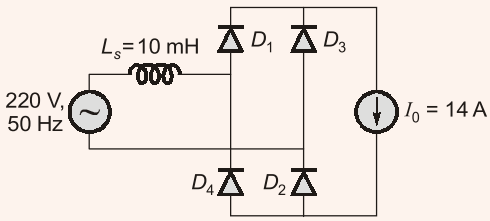
When $V_s = 72$ V and $V_0 = 48$ V

$$\alpha = \frac{2}{5}$$

$$\frac{2}{5} \le \alpha \le \frac{3}{5}$$

End of Solution

Q.50 The figure below shown an uncontrolled diode bridge rectifier supplied from a 220 V, 50 Hz , 1-phase ac source. The load draws a constant current $I_0 = 14$ A. The conduction angle of the diode D_1 in degrees (rounded off to two decimal places) is _____ .



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Ans. (224.17)

Average reduction in output voltage due to source inductance = ΔV_{d0}

$$\Delta V_{d0} = 4\ fL_s\ .\ I_0$$
$$= 4 \times 50 \times (10.10^{-3}) \times 14$$
$$\Delta V_{d0} = 28\ \text{V}$$
$$\Delta V_{d0} = \frac{V_m}{\pi}[(\cos\alpha - \cos(\alpha+\mu)] \qquad \alpha = 0$$
$$28 = \frac{V_m}{\pi}[1-\cos\mu]$$
$$28 = \frac{220.\sqrt{2}}{\pi}[1-\cos\mu]$$
$$0.282 = 1 - \cos\mu$$
$$\cos\mu = 0.717$$
$$\mu = 44.17$$

$\therefore$ Conduction angle of diode = 180° + 44.17° = 224.17°

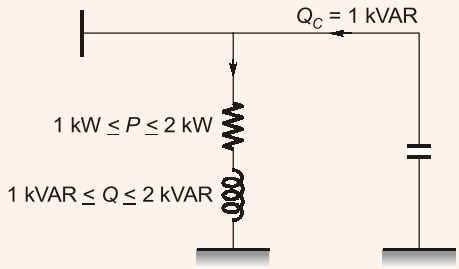
End of Solution

Q.51 A load is supplied by a 230 V, 50 Hz source. The active power P and the reactive power Q consumed by the load are such that 1 kW $\le P \le$ 2 kW and 1 kVAR $\le Q \le$ 2 kVAR. A capacitor connected across the load for power factor correction generates 1 kVAR reactive power. The worst case power factor after power factor correction is

(a) 0.447 lag (b) 0.707 lag

(c) 0.894 lag (d) 1

Ans. (b)



Load p.f.

$$\cos\phi_1 = \cos\left[\tan^{-1}\frac{Q}{P}\right] = \cos\left[\tan^{-1}\frac{1}{1}\right]$$
$$= 0.707\ \text{lag}$$
$$Q_c = P\ [\tan\phi_1 - \tan\phi_2]$$
$$1 = 1(\tan\cos^{-1}0.707 - \tan\phi_2)$$
$$\phi_2 = 45°$$
$$\Rightarrow \quad \cos\phi_2 = 0.707\ \text{lag}$$

End of Solution

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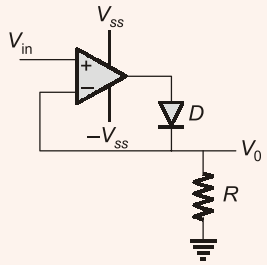
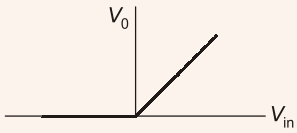
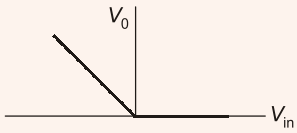
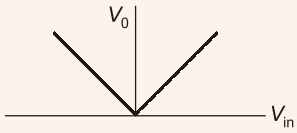
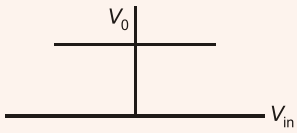
Q.52 The approximate transfer characteristic for the circuit shown below with an ideal operational amplifier and diode will be



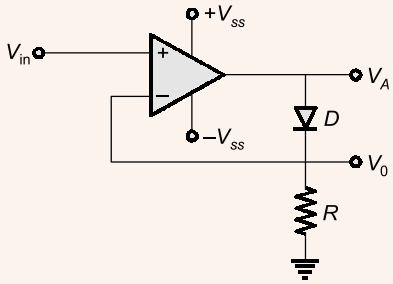
(a)


(b)


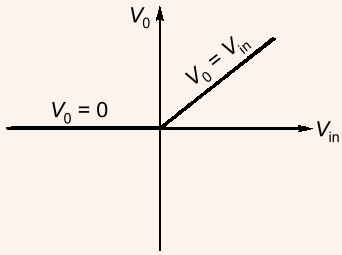
(c)


(d)


Ans. (a)



$V_{in} > 0$ $V_A = +V_{55}$, D on, $V_0 = V_{in}$
$V_{in} < 0$ $V_A = -V_{55}$, D off, $V_0 = 0$



End of Solution

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Q.53 A function $f(x)$ is defined as $f(x) = \begin{cases} e^x & x < 1 \\ \ln x + ax^2 + bx, & x \geq 1 \end{cases}$, where $x \in R$ which one of the following statements is TRUE?

(a) $f(x)$ is **NOT** differentiable at $x = 1$ for any values of a and b.

(b) $f(x)$ is differentiable at $x = 1$ for the unique values of a and b.

(c) $f(x)$ is differentiable at $x = 1$ for all the values of a and b such that $a + b = e$.

(d) $f(x)$ is differentiable at $x = 1$ for all values of a and b.

Ans. (a)

$$f(x) = \begin{cases} e^x & x < 1 \\ \ln x + ax^2 + bx & x \geq 1 \end{cases}$$

$$\text{L.H.D} = \lim_{x \to 1} \frac{f(x) - f(1)}{x - 1}$$

$$= \lim_{x \to 1} \frac{e^x - (a+b)}{x - 1} = \lim_{x \to 1} \frac{e^x}{1} = e$$

$$\text{R.H.D} \quad \lim_{x \to 1} \frac{f(x) - f(1)}{x - 1}$$

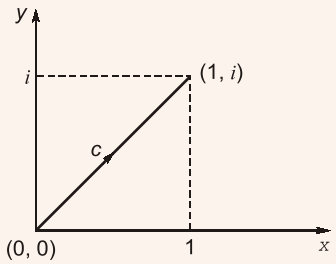
$$= \lim_{x \to 1} \frac{\ln x + ax^2 + bx - a + b}{x - 1} = \lim_{x \to 1} \frac{\frac{1}{x} + 2ax + b}{1} = 1 + 2a + b$$

L.H.D ≠ R.H.D.

∴ $f(x)$ is not derivable at $x = 1$

End of Solution

Q.54 Consider the line integral $I = \int_c (x^2 + iy^2)dz$, where $z = x + iy$. The line c is shown in the figure below.



The value of I is

(a) $\frac{1}{2}i$ (b) $\frac{2}{3}i$

(c) $\frac{3}{4}i$ (d) $\frac{4}{5}i$

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Ans. (b)

From the diagram C is $y = x$

$$I = \int_C (x^2 + iy^2)\, dz = \int_C (x^2 + iy^2)(dx + idy)$$

$$= \int_C (x^2 + ix^2)(dx + idx)$$

$$= \int x^2 dx + ix^2 dx + ix^2 dx - x^2 dx$$

$$= 2i\int_0^1 x^2 dx = 2i\left(\frac{x^3}{3}\right)\Big|_0^1 = \frac{2i}{3}$$

End of Solution

Q.55 The positive, negative and zero sequence reactances of a wye-connected synchronous generator are 0.2 pu, 0.2 pu and 0.1 pu respectively. The generator is on open circuit with a terminal voltage of 1 pu. The minimum value of the inductive reactance, in pu, required to be connected between neutral and ground so that the fault current does not exceed 3.75 pu if a single line to ground fault occurs at the terminals is _____ . (assume fault impedance to be zero). (Give the answer up to one decimal place.)

Ans. (#)

$$Z_1 = 0.2$$
$$Z_2 = 0.2$$
$$Z_0 = 0.1$$
$$V_{Th} = 1$$
$$I_f = 3.75$$

For LG fault;

$$I_f = \frac{3V_{Th}}{Z_1 + Z_2 + Z_0 + 3Z_n}$$

$$3.75 = \frac{3 \times 1}{0.2 + 0.2 + 0.1 + 3Z_n}$$

$$Z_n = 0.1 \text{ pu.}$$

End of Solution

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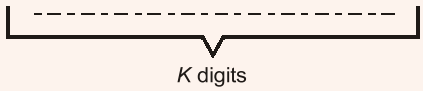
GENERAL ABILITY

Q.1 The probability that a *k*-digit number does NOT contain the digits 0, 5 or 9 is

(a) 0.3^k (b) 0.6^k

(c) 0.7^k (d) 0.9^k

Ans. (c)



Each digit can be filled in 7 ways as 0, 5 and 9 is not allowed, so each of these places can be filled by 1, 2, 3, 4, 6, 7, 8 so required probability is $\left(\frac{7}{10}\right)^K$ or 0.7^K

$$\frac{fC}{TC} = \frac{7^K}{10^K} = 0.7^K$$

End of Solution

Q.2 Find the smallest number *y* such that that y x 162 is a perfect cube.

(a) 24 (b) 27

(c) 32 (d) 36

Ans. (d)

$y \times 162$ = Perfect cube

Option, $y = 24 \Rightarrow 2^3 \times 3\ (2 \times 81) \neq$ Not perfect cube

$y = 27 \Rightarrow 3^3 \times (2 \times 3^4) \neq$ Not perfect cube

$y = 32 \Rightarrow 2^5 \times 2 \times 3^4 \neq$ Not perfect cube

$y = 36 \Rightarrow 2^2 \times 3^2 \times 2 \times 3^4 = 2^3 \times 3^6 = (2 \times 3^2)^3$ is a perfect cube

Hence the answer is, $y = 36$

End of Solution

Q.3 After Rajendra Chola returned from his voyage to Indonesia, he _____ to visit the temple in Thanjavur.

(a) was wishing (b) is wishing

(c) wished (d) had wished

Ans. (c)

Correct option is; Wished

After Rajender Chola **retured** from his voyage to Indonesia, he **wished** to visit the temple in Thanjavur.

Both are events of past. Use of past perfect form is unwarranted as it reflects part of past.

End of Solution

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Q.4 Research in the workplace reveal that people work for many reasons _____ .

(a) money beside
(b) beside money
(c) money besides
(d) besides money

Ans. (d)

Besides money

Research in the work place reveals the people warks for many reasons **besides money**.

Besides conveys the meaning of 'in addition'

Beside means 'next to'

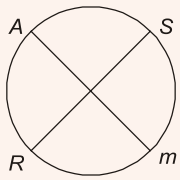
End of Solution

Q.5 Rahul, Murali, Srinivas and Arul are seated around a square table. Rahul is sitting to the left of Murali. Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other?

(a) Rahul and Murali
(b) Srinivas and Arul
(c) Srinivas and Murali
(d) Srinivas and Rahul

Ans. (d)

Following seating arrangement can be drawn



Therefore correct option is (d).

End of Solution

Q.6 "The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history."

Which of the following statements best reflects the author's opinion?

(a) Nationalists are highly imaginative
(b) History is viewed through the filter of nationalism
(c) Our colonial past never happened
(d) Nationalism has to be both adequately and properly imagined.

Ans. (b)

History is viewed through the filter of rationalism.

End of Solution

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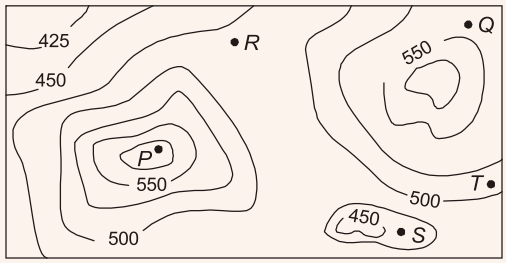
Q.7 A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25 m intervals in this plot. If in a flood, the water level rises to 525 m, which of the villages *P*, *Q*, *R*, *S*, *T* get submerged?



(a) *P*, *Q*
(b) *P*, *Q*, *T*
(c) *R*, *S*, *T*
(d) *Q*, *R*, *S*

Ans. **(c)**

P will not get submerged as it is @ 550. So *P* is not present in correct options. Hence (i) and (ii) options are incorrect. Now compare *Q* and *T*. As *T* is between 500 and 525. T will get submerged. Hence ans (c) as among option *C* and *D*. *T* is present in only option (c).

End of Solution

Q.8 The expression $\frac{(x+y)-|x-y|}{2}$ is equal to

(a) the maximum of x and y
(b) the minimum of x and y
(c) 1
(d) none of the above

Ans. **(b)**

$$\frac{(x+y)-|x-y|}{2} \quad \ldots(i)$$

If $x > y$ $\quad |x-y| = x - y$;
If $x < y$ $\quad |x-y| = y - x$

Now if $x > y$, above expression (i) becomes

$$\frac{(x+y)-(x-y)}{2} = \frac{2y}{2}$$

$= y$ = minimum of (x, y) as $x > y$

Now if $x < y$;

$$\frac{x+y-(y-x)}{2} = \frac{2x}{2} = x = \text{minimum of } (x, y) \text{ as } x < y$$

Therefore correct answer is option (b).

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Alternate solution:

Use easy values,

$$x = 1 \text{ and } y = -2$$

Now, $$\frac{(1-2)-|1-(-2)|}{2} = -2$$

or $$x = 2 \text{ and } y = -1$$

$$\frac{(2-1)-|2-(-1)|}{2} = \frac{1-3}{2} = -1$$

which is minimum of (x, y).

Therefore, correct answer is option (b).

End of Solution

Q.9 Arun, Gulab, Neel and Shweta must choose one shirt each from a pile of four shirts coloured red, pink, blue and white respectively. Arun dislikes the colour red and Shweta dislikes the colour white. Gulab and Neel like all the colours. In how many different ways can they choose the shirts so that no one has a shirt with a colour he or she dislikes?

(a) 21 (b) 18

(c) 16 (d) 14

Ans. (d)

As there are 4 people A, G, N, S and four colours so without any restriction total ways have to be $4 \times 4 = 16$.

Now, Arun $\rightarrow$ dislikes Red and Shweta dislikes white so $16 - 2 = 14$ ways.

Therefore correct answer should be option (d).

Alternate solution:

Only one option is less than 16.

Therefore correct answer should be option (d).

End of Solution

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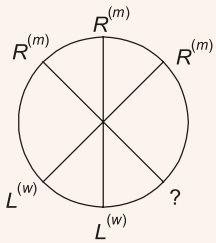
Q.10 Six people are seated around a circular table. There are at least two men and two women. There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is

(a) 2 (b) 3

(c) 4 (d) Cannot be determined

Ans. **(a)**

Out of six people. 3 place definitely occupied by right handed people as at least 2 women are there so these two will sit adjacently. Now as only on seat is left it will be occupied by a left handed man because on right side of this seat is sitting an right handed man.



? have to be a left handed man.

Here, $R^{(m)}$ indicates right handed man and $L^{(w)}$ indicates left handed women. Therefore answer should be only 2 women.

End of Solution

❍❍❍❍